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COVER

California halibut, *Paralichthys californicus*. Department of Fish
and Game file photograph

ERRATA

Van Vuren, D., T.G. Moore, and C.A. Ingels. 1998. Prey selection by barn owls using artificial nest boxes. *California Fish and Game* 84:127-132.

Before printing, the editors mistakenly substituted "Mean" as the heading for the summary column in Tables 1 and 2. The appropriate heading for that column is "Overall." Also, the caption of Table 1 contained extraneous words. The correct tables are printed here.

Table 1. Percent frequency of occurrence of prey items in diets of barn owls in San Joaquin County, California, as determined at approximately 5-week intervals from January to August 1996.

	<u>1 Feb</u>	<u>2 Mar</u>	<u>7 Apr</u>	<u>11 May</u>	<u>20 Jun</u>	<u>3 Aug</u>	<u>Overall</u>
Gopher	32	30	33	60	55	83	42
California vole	51	42	40	30	35	13	42
Deer mouse	22	32	26	17	10	6	18
House mouse	17	30	21	10	7	3	15
Bird	4	2	8	1	10	13	5
Rat	4	3	6	1	1	0	3
n	254	111	42	89	94	31	621

Table 2. Body mass of Botta's pocket gophers in diets of barn owls in San Joaquin County, California, as determined at approximately 5-week intervals from January to August 1996.

	<u>1 Feb</u>	<u>2 Mar</u>	<u>7 Apr</u>	<u>11 May</u>	<u>20 Jun</u>	<u>3 Aug</u>	<u>Overall</u>
Median (g)	69	90	79	52	67	53	61
Range (g)	28-212	39-231	41-182	20-199	25-194	22-162	20-231
n	55	24	13	82	66	37	277

Editors' Note: this page was left out of 85(1) due to a printer's error.

MOVEMENT OF CALIFORNIA HALIBUT ALONG THE COAST OF CALIFORNIA

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From April 1992 to April 1997, volunteers tagged 26,827 California halibut, *Paralichthys californicus*, from Morro Bay, California to Isla Coronado del Norte, Baja California, Mexico. Catch-per-unit-effort was greater than average from November through March and was below average from April through October. The majority of recaptured halibut remained in the same general region where they were tagged, not moving more than 5.5 km. However, some individuals moved great distances, 2 of them over 300 km. Halibut that moved more than 5.5 km exhibited no statistically significant directional preference, although more moved south. Total length and distance traveled were not significantly related. Mean movement increased in halibut >550 mm, but this increase was not statistically significant. Future tagging studies should include sufficient individuals >550 mm to determine whether the extent of movement changes as juveniles mature.

INTRODUCTION

The California halibut, *Paralichthys californicus*, is one of the most important commercial and recreational fishes in southern California and has consequently attracted research into many aspects of its biology. Recent work has investigated the distribution of larvae and juveniles (Allen et al. 1990, Kramer 1990, Moser and Watson 1990), growth and development (Gadomski et al. 1990, Innis 1990), age of sexual maturity (Love and Brooks 1990), spawning behavior (Caddell et al. 1990), and the history of the fishery (Barsky 1990). However, some fundamental questions remain regarding movements. Knowledge of the movement of adults and juveniles and the transport of eggs and larvae of any species is essential to successful management. If a species shows limited movement during all life stages, different localities in the species' range may require individualized management guidelines. On the other hand, if the species is far ranging, a much wider area may be managed as a unit (Hartman 1987). Tagging studies on rockfishes have been used to quantify the extent of movement in adults to better design management strategies for these species (Hartman 1987, Stanley et al. 1994). Ichthyoplankton sampling can be

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used to monitor the transport of eggs and larvae (McGowen 1993) and molecular techniques can be used to determine gene flow and infer the movement of eggs, larvae, and adults (Hedgecock and Bartley 1988, Bowen and Avise 1990).

Although California halibut have been reported to remain relatively stationary (Fitch and Lavenberg 1971, Haaker 1975, Tupen 1990), some halibut may travel long distances along the coast (Domeier and Chun 1995). Considering the degradation of California's coastal estuaries and wetlands, which are important nursery sites for this species (Kramer 1990), it is important to determine if populations potentially affected by this habitat loss are augmented by migration from more pristine areas, e.g., Baja California, Mexico. Tupen (1990) found that only 45% of California halibut recaptured in his study moved from their tagging location. Equal numbers of these fish traveled north and south, but those moving south traveled farther. Size and distance traveled were not related. A later tagging study by Domeier and Chun (1995) examined a larger sample size and produced different results. Whereas most halibut in this study also showed little movement, distance traveled was related to size; movement was greater for fish >500 mm total length (TL). Although equal numbers of moving halibut traveled north and south, those moving north traveled farther. Both of these studies agree that California halibut usually do not travel long distances. However, they disagree on whether movement increases with size and whether movement is random. Our study attempts to clarify some of these issues by reporting the movement of California halibut tagged along the coast of California. These data come from a continuing tagging program begun in April 1992 in cooperation with the Santa Monica Bay Halibut Derby. This is the longest continuous tagging study of California halibut to date.

METHODS

From April 1992 to April 1997, volunteers tagged California halibut along the coast from Morro Bay, California to Isla Coronado del Norte, Baja California, Mexico (Fig. 1). Most fish were tagged in Santa Monica Bay. Halibut were caught by hook and line and a tag was inserted on the eyed side above the pectoral fin, near the curve in the lateral line. Both spaghetti tags and t-bar tags were used. After recording TL, date, time, location, depth of capture, and tag number, halibut were released. Locations were recorded as general regions. In Santa Monica Bay these regions were approximately 5.5 km wide. Tags were printed with a phone number to facilitate reporting of recaptures. Almost all recaptures were by sport anglers using hook and line; only a few were taken in trawls.

Much of the tagging was done on board the charter boat *HAPPY MAN*. The number of halibut caught each month on board this vessel was divided by the number of anglers in the boat's log to determine the monthly catch-per-unit-effort (CPUE). Monthly values were compared to the average CPUE for the entire study to identify months of above and below average catch.

For each recaptured halibut, distance traveled between tagging and recapture was calculated using a nautical chart. Distances were measured as a straight line between the 2 capture sites. If this line crossed land, distance traveled was measured

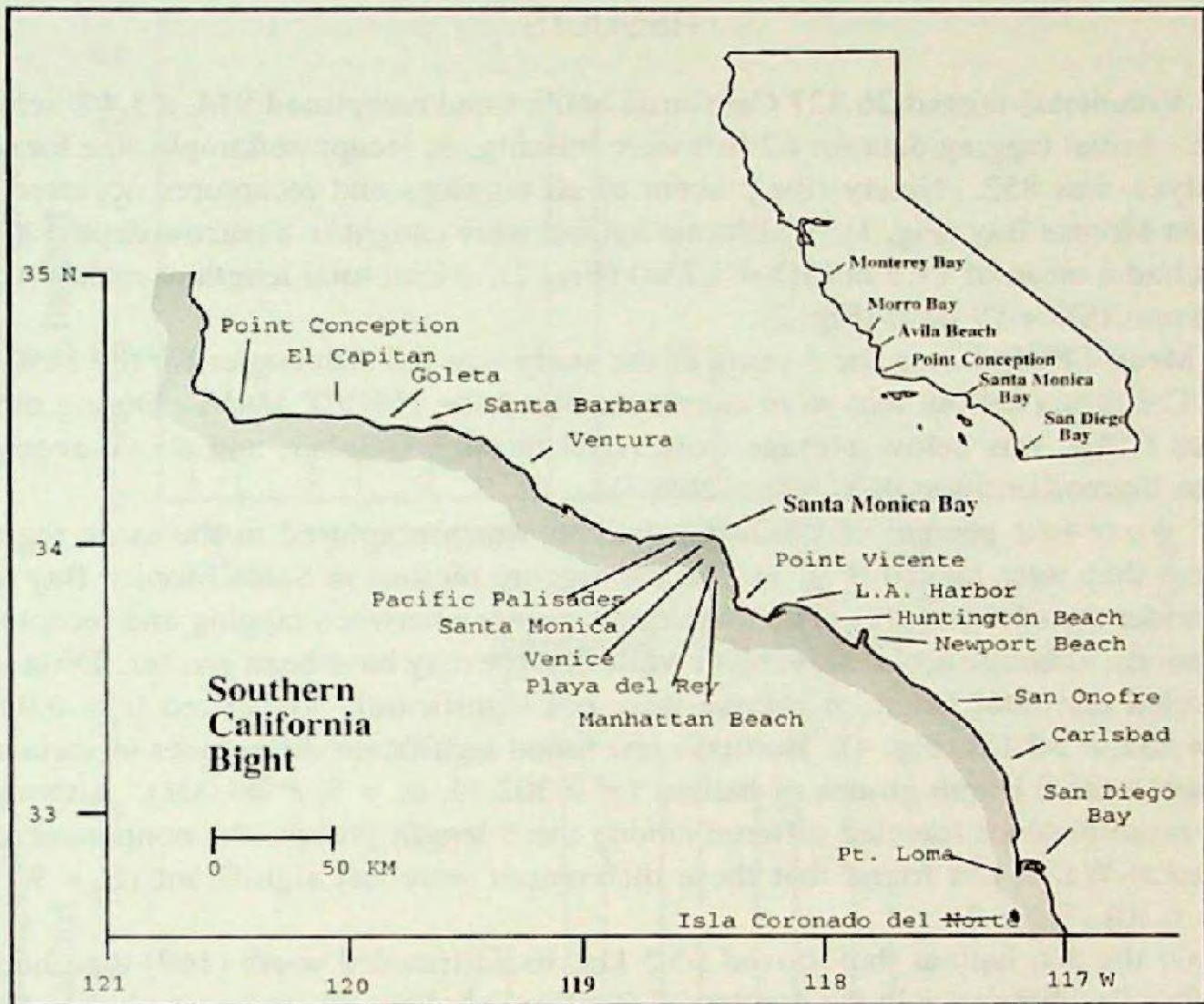


Figure 1. Map of California and the Southern California Bight showing the locations where California halibut moving more than 30 km were tagged or recaptured.

as the shortest distance between the 2 points while moving around the intervening land mass.

The association between length at release and distance traveled was measured with Spearman's rank correlation coefficient. Length at release was used since TL at recapture was sometimes not recorded. Additionally, recaptures were grouped by their TL at release into 6 groups: 201–350 mm, 351–400 mm, 401–450 mm, 451–500 mm, 501–550 mm, and >550 mm. Bartlett's test for homogeneity of variance was used to determine the proper statistic for identifying differences in movement between these groups. Median movement in each of the groups was then compared using the nonparametric Kruskal-Wallis test.

The direction of movement for all halibut was coded as either north or south. Of course, due to the orientation of the southern California coastline, many individuals actually moved northwest or southeast. An independent t-test with equal variances was performed on all moving halibut to determine whether northward or southward movement was more prevalent. The same test was also performed only on those halibut that had moved >30 km. Chi-square tests were used to determine whether significantly more halibut had moved north or south in each group.

RESULTS

Volunteers tagged 26,827 California halibut and recaptured 914, a 3.4% return rate. Initial tagging data for 62 fish were missing, so recapture sample size for our analysis was 852. Ninety-five percent of all taggings and recaptures occurred in Santa Monica Bay (Fig. 1). California halibut were caught in a narrow depth range that had a mean of 17.3 m (SD = 5.7 m) (Fig. 2). Mean total length at release was 426 mm (SD = 89 mm) (Fig. 2).

Mean CPUE during the 5 years of the study was 0.2 fish/angler for the 58% of the California halibut that were caught on board the *HAPPY MAN*. During most years CPUE was below average from April through October, and above average from November through March (Table 1).

Sixty-four percent of California halibut were recaptured in the same region where they were tagged (Fig. 3). As the tagging regions in Santa Monica Bay are no wider than 5.5 km, this is the maximum distance between tagging and recapture locations, although actual movement while at large may have been greater. Distance traveled and total length at release were not significantly associated ($r_s = 0.048$, $df = 832$, $P > 0.10$) (Fig. 4). Bartlett's test found significant differences in variance between the 6 length groups of halibut ($\chi^2 = 302.15$, $df = 5$, $P < 0.001$). Although the mean distance traveled differed among the 6 length groups, the nonparametric Kruskal-Wallis test found that these differences were not significant ($H = 9.16$, $P = 0.10$) (Table 2).

Of the 306 halibut that moved >5.5 km, more traveled south (169) than north (137). The difference in the number of California halibut moving in each direction was not significant ($\chi^2 = 3.38$, $df = 1$, $P = 0.07$). Furthermore, the difference between the 2 groups in mean distance traveled was not significant (north: 17.8 km, south: 15.1 km; $t = 0.62$, $df = 304$, $P = 0.53$). Differences between northward- and southward-moving California halibut increased when only halibut moving >30 km were considered. A larger proportion of individuals traveled south (16 versus 8), but the difference in number between these groups was still not significant ($\chi^2 = 2.66$, $df = 1$, $P = 0.10$). However, fish traveling north moved a significantly greater distance (167.1 km) than those traveling south (85.7 km) ($t = 2.39$, $df = 22$, $P = 0.03$).

DISCUSSION

Angler success for California halibut in southern California appears related to spawning periodicity. California halibut spawn primarily from February to April off California, with an occasional smaller peak from July to October (Lavenberg et al. 1986, Walker et al. 1987, Moser and Watson 1990). The CPUE was high during the peak of the spawning season, February and March, and then decreased in April. Under hatchery conditions, halibut have been observed to feed more during the spawning season (D. Oda and J. Rounds, Natural History Museum of Los Angeles County, personal communication). Hence, this decline in CPUE may be related to the change in feeding behavior.

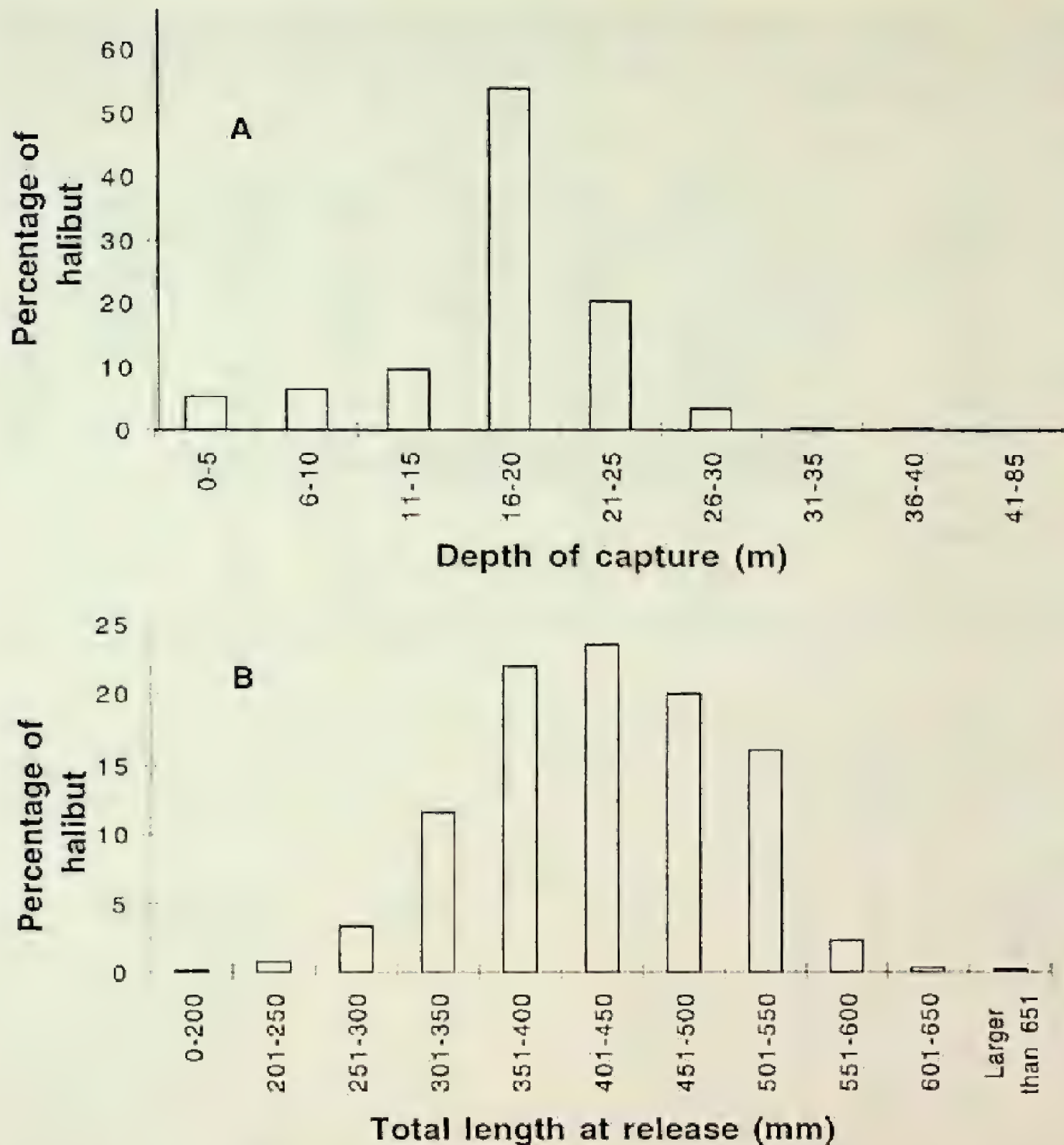


Figure 2. Proportionate distribution of a) depth of capture and b) total length at release for California halibut tagged and recaptured in the Southern California Bight, 1992–1997.

However, the CPUE pattern was inversely associated with the number of anglers on the *HAPPY MAN*. In months of above-average CPUE a below-average number of anglers was usually on board, and vice versa. This inverse relationship occurred in 72% of the months under study. Thus, the CPUE pattern may simply reflect reduced fishing effort and not a change in California halibut catchability.

Our recapture data support the conclusion of other studies (Fitch and Lavenberg 1971, Haaker 1975, Tupen 1990, Domeier and Chun 1995) that most California halibut tend to remain in the same area for long periods. Most halibut in our study did not leave the region where they were tagged. Two of these sedentary halibut were recaptured after 34 and 41 months. Another individual recaptured after 48

Table 1. Number of California halibut tagged in the Southern California Bight, 1992–1997. Bold underlined numbers indicate months in which catch-per-unit-effort was higher than the mean for the entire study.

Month	Year					
	1992	1993	1994	1995	1996	1997
January		<u>129</u>	<u>545</u>	63	<u>382</u>	<u>143</u>
February		<u>278</u>	<u>347</u>	<u>611</u>	<u>290</u>	<u>667</u>
March		<u>577</u>	<u>297</u>	<u>501</u>	276	<u>864</u>
April	40	263	336	<u>244</u>	156	<u>387</u>
May	114	55	31	131	<u>359</u>	
June	112	240	125	185	150	
July	66	117	206	316	30	
August	279	82	138	201	251	
September	271	<u>455</u>	216	149	<u>718</u>	
October	230	<u>412</u>	179	87	136	
November	<u>271</u>	<u>352</u>	87	<u>316</u>	<u>351</u>	
December	146	<u>312</u>	<u>217</u>	<u>345</u>	<u>306</u>	

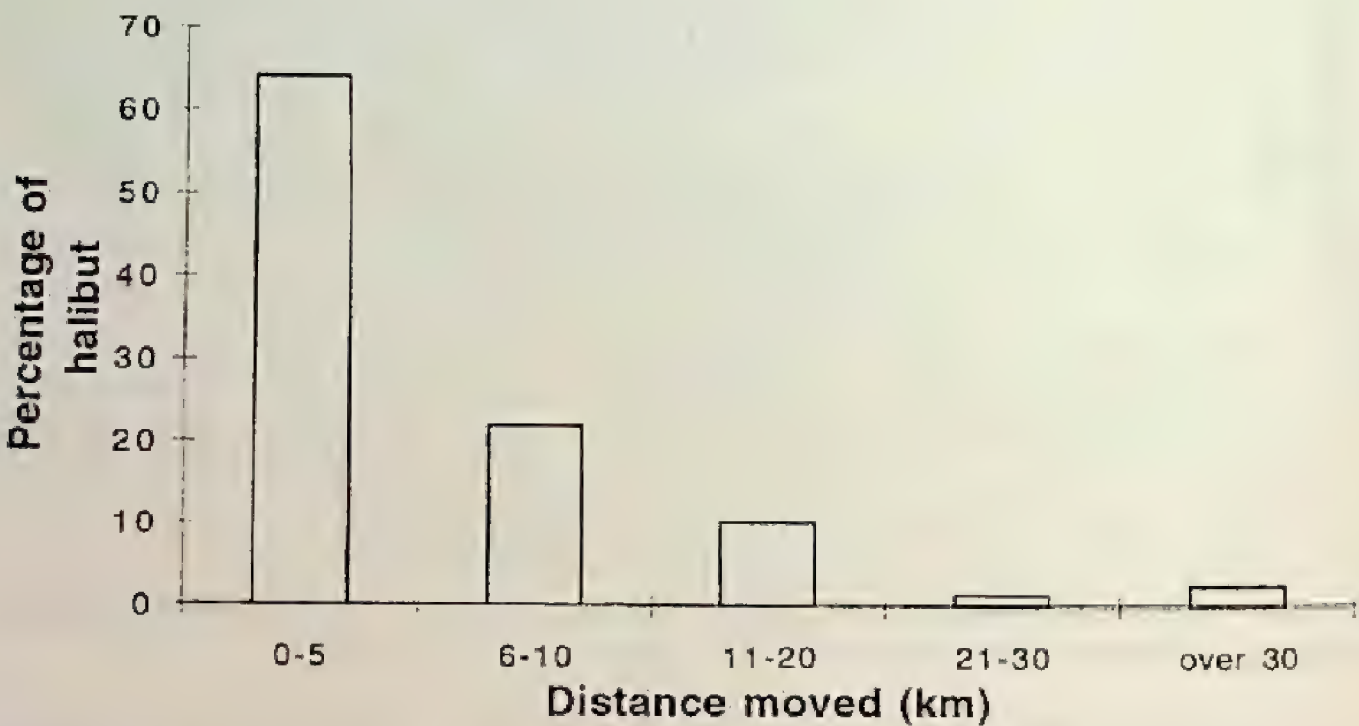


Figure 3. Distance traveled by recaptured California halibut, 1992–1997.

months had moved <10 km. The consistently low mean movement in size classes ≤ 550 mm explains why we found no correlation between total length and movement. Domeier and Chun (1995) found an increase in mean movement at 500 mm TL. Tupen (1990) found no relationship between size and distance traveled; however, his study's sample size was only 40 individuals, compared to 839 in Domeier and Chun (1995) and 852 in our study. Although we found that mean movement increased in fishes >550 mm, this increase was not statistically significant. This

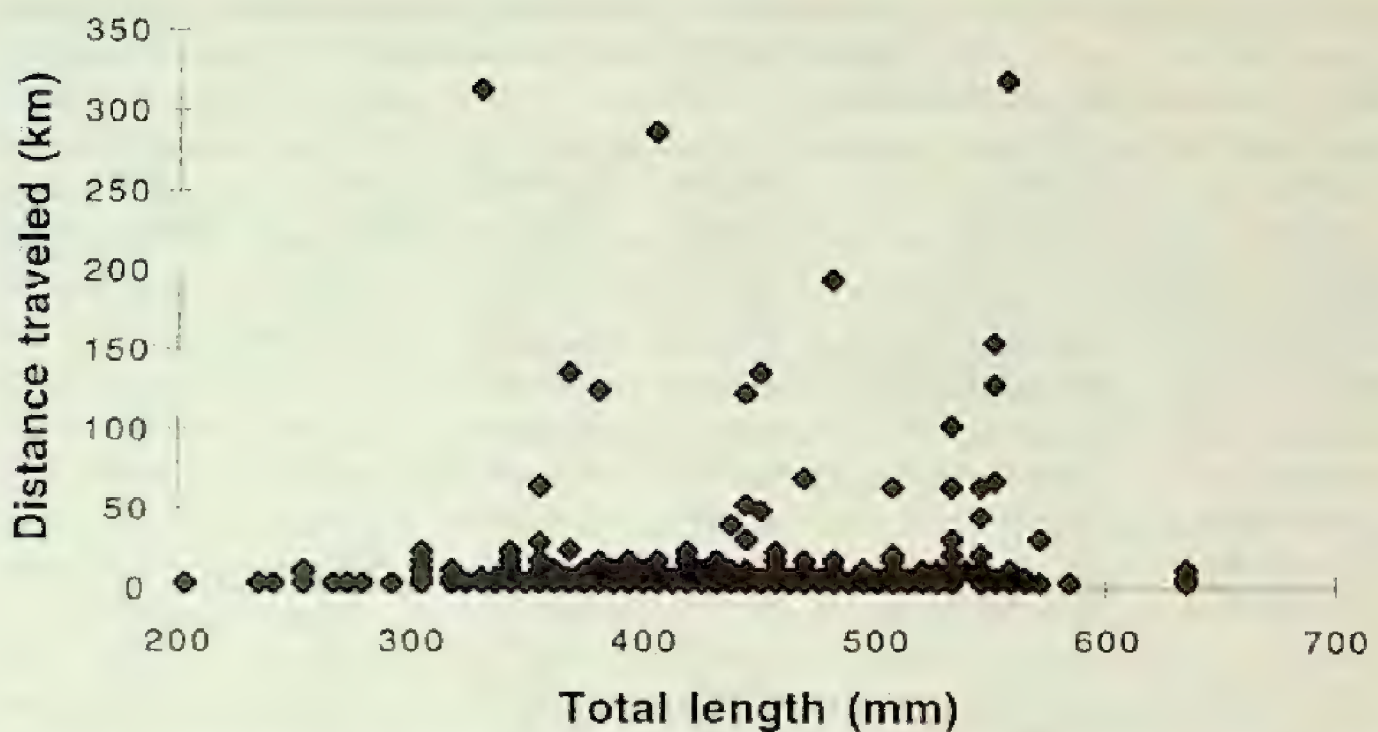


Figure 4. Comparison of distance traveled and total length at release for California halibut tagged in the Southern California Bight, 1992–1997.

Table 2. Mean distance traveled by California halibut tagged in the Southern California Bight, 1992–1997. Mean distance is <5.5 km for some groups because movement for individuals that did not leave the region in which they were tagged was considered to be 0 km.

Total Length (mm)	Distance traveled (km)		
	Mean	SD	n
201–350	5.5	32.0	94
351–400	5.3	15.7	174
401–450	5.3	21.8	215
451–500	4.6	17.7	203
501–550	5.6	13.7	135
>550	29.5	72.3	25

non-significance may have been due to small sample size and larger standard deviation in the >550 mm size class. Increased tagging of larger California halibut is necessary to determine whether mean movement increases at greater total lengths.

Some California halibut do move quite far (Table 3). Two individuals (330 and 559 mm TL) tagged in Santa Monica Bay and recaptured in Morro Bay traveled 313 and 319 km. Another individual (406 mm TL) moved south 287 km from Avila Beach to Santa Monica Bay. Although 2 of these individuals were <550 mm, a general increase in movement with increasing size may be the result of changing behavior patterns as juveniles mature.

Juveniles use the protected waters of bays and estuaries as nursery areas (Plummer et al. 1983, Allen 1988). This reduces predation by separating juveniles from potential predators and increases growth by nutrient enrichment (Kramer 1990). Juveniles leave these protected waters for the open coast at about 140–200 mm standard length

Table 3. Tagging and recapture information in order of recapture date for California halibut moving >30 km. See Fig.1 for the location of tagging and recapture sites. Total lengths are those measured at the time of release.

Tagging Location	Recapture Location	Tagging Date	Recapture Date	Distance Moved (km)	Total Length (mm)
Manhattan Beach	Morro Bay	4/4/92	10/10/92	319	559
Manhattan Beach	Ventura River	8/23/92	11/9/92	102	533
Playa del Rey	Huntington Beach	8/23/92	3/15/93	63	508
Playa del Rey	Huntington Beach	6/19/92	3/15/93	63	533
Santa Monica	Pt. Loma	9/13/92	3/16/93	194	483
Santa Monica	Huntington Beach	9/10/92	6/16/93	69	470
Santa Monica	Goleta	2/14/93	7/23/93	135	368
Playa del Rey	El Capitan	3/9/93	10/3/93	154	552
Playa del Rey	Huntington Beach	9/7/93	11/7/93	63	356
Venice	L.A. Harbor	3/20/93	1/21/94	44	546
Point Vicente	Carlsbad	9/4/93	2/27/94	124	381
Venice	Santa Barbara	12/2/93	4/1/94	122	445
Pacific Palisades	L.A. Harbor	3/29/94	6/28/94	52	445
L. A. Harbor	Newport Beach	6/2/94	9/14/94	30	533
Playa del Rey	Huntington Beach	9/23/94	6/23/95	63	546
Santa Monica	L.A. Harbor	2/4/95	7/1/95	48	451
San Diego Bay	Coronado de Norte	6/15/95	7/21/95	30	572
Playa del Rey	Morro Bay	4/22/93	10/11/95	313	330
Playa del Rey	Santa Barbara	8/30/94	10/13/95	128	552
Huntington Beach	Playa del Rey	7/3/94	10/20/95	64	356
Venice	Huntington Beach	12/4/94	3/3/96	67	552
Playa del Rey	L.A. Harbor	12/8/95	6/9/96	39	438
Playa del Rey	San Onofre	9/16/95	6/19/96	135	451
Avila Beach	Playa del Rey	7/21/93	7/9/96	287	406
Playa del Rey	Point Vicente	9/21/96	2/8/97	30	445

(Haaker 1975, Kramer 1990). Since all halibut tagged in this study were >200 mm, their movements do not represent this primary emigration from nursery areas. In fact, the open coast of Santa Monica Bay is not a significant nursery area for juvenile California halibut, except for Malaga Cove near PalosVerdes (Allen et al. 1990, Allen and Herbinson 1990).

Potential increases in mean movement may be linked to sexual maturity in California halibut. Love and Brooks (1990) found that all males in their study reached sexual maturity by 320 mm TL, and all females by 590 mm TL. Changes in extent of movement may be an adult behavior not normally found in juveniles. Unfortunately, since the largest halibut in this and previous tagging studies are almost all under the sport fishery size limit of 559 mm TL, we are not able to positively identify a potentially common adult behavior. Of the recaptured halibut in the Domeier and Chun (1995) study, 141 (17%) were >550 mm TL, compared to 25 (3%) in our study. Additionally, because most of the fishing effort in our study

was concentrated in water between 16 and 20 m deep, our results do not shed light on the onshore vs. offshore movement of California halibut.

The larger proportion of California halibut that moved south in this study may be an artifact of the greater number of volunteer taggers located just south of Santa Monica Bay in Orange County than north of it in Ventura County. The greater likelihood of recapturing fish to the south may have biased our results. California halibut that moved >30 km exhibited significantly greater northward than southward movement. However, among all halibut that moved outside the area where tagged, there was no significant difference in north and south movements. Domeier and Chun (1995) found greater mean movement to the north, but attributed this to the possibility that halibut moving long distances to the south would enter Mexican waters and therefore not be reported if recaptured. This may explain our results also. Fish moving southward long distances were likely to reach Mexico and therefore be lost to this study. We are, therefore, losing the extreme cases of southward movement from our database. By tagging mainly in southern California, our study, and that of Domeier and Chun, may be biased in determining directionality of halibut movement. This conclusion is supported by Tupen's (1990) tagging study in central California, which found greater mean movement in a southerly direction. We are unable to determine whether the magnitude of California halibut movement is greater in one particular direction.

Alternatively, the greater extent of northward movement may be due to oceanographic conditions. Either long-term interdecadal warming trends or short-term El Niño events may cause northward movement of halibut populations (Murphree and Reynolds 1995, MacCall 1996). However, since the vast majority of halibut show little movement, oceanographic conditions do not appear to be a mechanism for geographical shifts in population. Oceanographic conditions are more likely to affect the transport of eggs and larvae (Allen et al. 1990).

It is not clear whether long movements are typical of adult California halibut or whether only a small proportion of individuals move long distances. Even if movement is uncommon among most adults, the movement of a few individuals may still be an important factor in the biology of California halibut by causing significant gene flow (Slatkin 1987).

Any work on genetic variation between populations should consider the possible impact of adult movement. Continued sampling of ichthyoplankton along the California coast is also needed to provide a direct estimate of the importance of egg and larva transport to the biology of this species. Combined with long-term tagging programs concentrated on larger adults, all of these studies would provide information to manage this important fishery resource. This work may eventually explain why some California halibut make long treks along the California coast.

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EXPANDABLE AND ECONOMICAL LONG-TERM COLLARS FOR JUVENILE MULE DEER

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We adapted the expandable collars used by others on young mouflon sheep, *Ovis musimon*, for use on juvenile mule deer, *Odocoileus hemionus*. We used these collars to investigate survivorship and cause-specific mortality among these cervids during 1994–1998. The collars were economical and simple to construct, and retention rate among 109 juvenile mule deer was >98%. Even after 2.5 years, no collars appeared to fit too tightly and we observed no evidence of injury to animals. These collars offer a dependable and economical alternative to expensive, factory-made, expandable collars.

INTRODUCTION

Investigators have devised a variety of collars for attaching radio transmitters to ungulates (Bleich et al. 1990, Bon and Cugnasse 1992, Smith et al. 1998 for reviews). Attachment of telemetry collars, however, can be problematic for some species (Bleich et al. 1990). Moreover, because of the need to provide for future growth, special consideration has been given to collar designs for neonates and juveniles. Bon and Cugnasse (1992) and Smith et al. (1998) developed and evaluated expandable collars for young mouflon sheep, *Ovis musimon*, and elk, *Cervus elaphus*. Although Bon and Cugnasse (1992) used their collars primarily for marking purposes, they did attach 10 radio transmitters to young mouflon sheep using their collar design. To prevent the apparently heavy telemetry package from dangling below the animal's neck, Bon and Cugnasse (1992) inserted a foam spacer between the collar and neck of the animal.

During an investigation of cause-specific mortality among mule deer, *Odocoileus hemionus*, inhabiting eastern California, we modified the collar design of Bon and Cugnasse (1992) and used it to attach telemetry packages to juveniles. In this paper, we describe our method of attaching transmitters to these collars using our modifications and evaluate safety and effectiveness for monitoring mortality among these cervids.

STUDY AREA

We conducted research in Round Valley (37°24'N, 118°34'W), Inyo and Mono counties, California, on a winter range used by migratory mule deer. Round Valley is situated on the western edge of the Great Basin, at the eastern base of the Sierra Nevada; consequently, it receives little precipitation because of the rainshadow cast by the mountain range. Vegetation in Round Valley is typical of much of the Great Basin and the shrub component is largely bitterbrush, *Purshia tridentata*; sagebrush, *Artemisia tridentata*; blackbrush, *Coleogyne ramosissima*; Mormon tea, *Ephedra* spp.; desert peach, *Prunus andersonii*; rabbitbrush, *Chrysothamnus nauseosum*; mountain mahogany, *Cercocarpus betuloides*; and ceanothus, *Ceanothus greggii*. Additional descriptions of Round Valley are provided by Bleich et al. (1996), Davis et al. (1996), and Pierce et al. (1998).

METHODS

We captured juvenile mule deer with a net-gun fired from a helicopter (Krausman et al. 1985). We determined the gender and obtained a variety of biological samples for each deer and fitted each animal with a radio transmitter containing a mortality sensor having a 6-hour delay for use in our research (Pierce and Bleich 1995¹, 1996²). We used radio transmitters manufactured by Lotek Engineering, Inc.³ (Model LMRT-2; Newmarket, Ontario, Canada), Telonics, Inc.³ (Model 400, S6A, 5.5 hr; Mesa, Arizona, USA), and Advanced Telemetry Systems, Inc.³ (Model Trans-uC-Mort-6.5hr, Ext Deer Fawn; Isanti, Minnesota, USA). Each brand of transmitter had a minimum expected life of at least 2 years under field conditions. During November–April, we monitored telemetry signals daily; during May–June, weekly; and during July–October when deer were on their summer ranges, monthly. When a mortality signal was received, we immediately attempted to retrieve the carcass and determine the cause of death.

We adapted the collar design of Bon and Cugnasse (1992) for attaching transmitters to juvenile deer. We estimated typical neck size of adult male (56.0 cm) and female (35.0 cm) mule deer using data from Anderson et al. (1974) and measurements obtained from animals captured in our study area. Transmitters were attached to short tabs of the manufacturer's standard collar material when received. We then modified that assembly by attaching an expandable collar (Fig.1), similar to the configuration described by Bon and Cugnasse (1992). We threaded a piece of 13-mm-wide elastic through 30-mm tubular webbing made of Perlon®³; this material is used in mountaineering applications and is readily available. The elastic

¹ Pierce, B.M. and V.C. Bleich. 1995. California deer management: The Round Valley investigation. California Hunter Magazine 4(4):32-33.

² Pierce, B.M. and V.C. Bleich. 1996. Round Valley deer study. Mule Deer 2(4):10-13.

³ Reference to trade names does not imply endorsement by the California Department of Fish and Game.

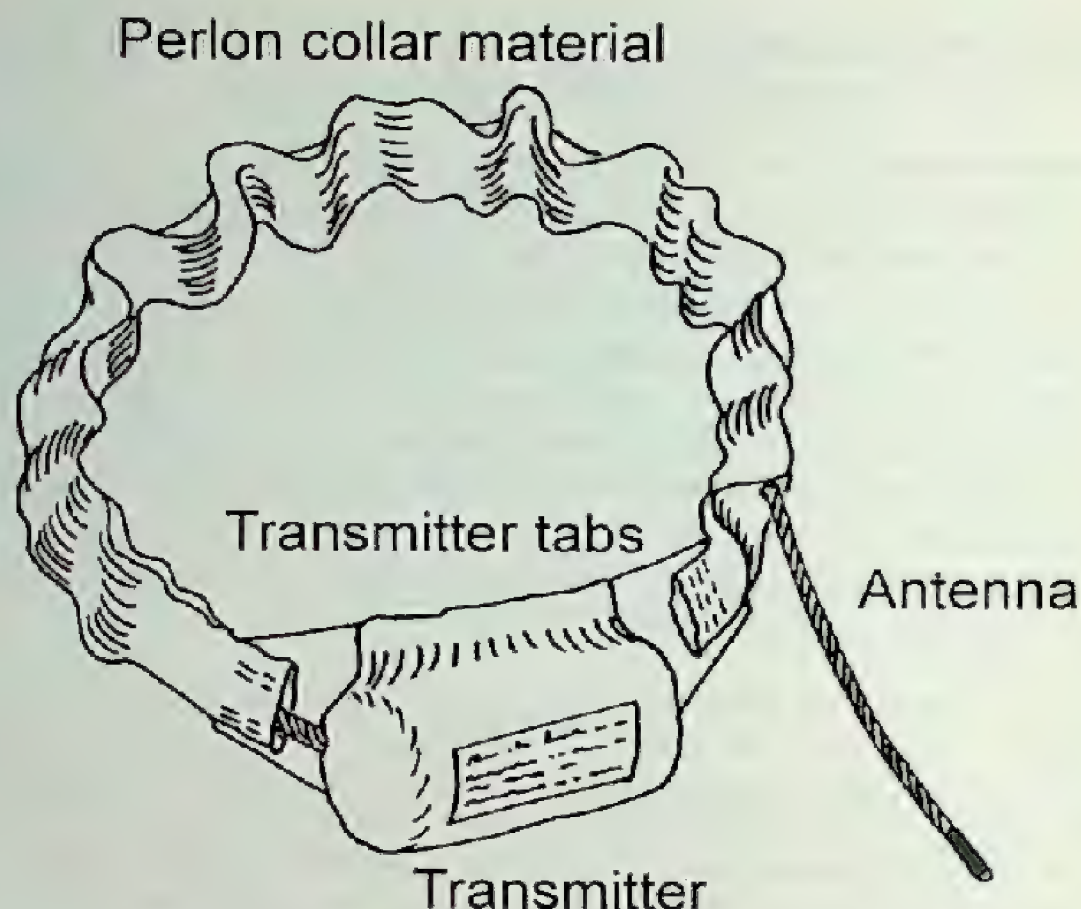


Figure 1. Three-dimensional view of representative radio transmitter attached to an expandable collar. Vinyl tape, described in the text as being used to protect the stitching, is intentionally not shown in order to reveal additional details.

had an expansion ratio of 1.5:1 and we calculated the length of elastic and tubular webbing (collar material) necessary to fit the neck of an adult male or female deer, as appropriate. We trimmed tabs on the transmitters to approximately 3 cm before sewing them with heavy, waxed thread to the Perlon® in order to maximize the proportion of the collar circumference that was expandable. We then wrapped the stitches with vinyl tape to prevent their snagging on vegetation. The antenna for each transmitter was threaded through the tubular webbing that composed the outer sleeve of the collar and exited on the opposite side of the transmitter from which it originated, pointing toward the ground. We used a flame to melt the frayed ends of the Perlon® webbing, and a hot 16-d nail to melt a hole in the Perlon® webbing from which the antenna exited. The contracted circumferences of collars (including the tabs of factory collar material) were about 28 cm for males and about 20 cm for females. Upon capture, we slipped these expandable collars over the heads of young deer; the fact that the collar allowed for growth of the animals made this possible. These collars were designed to be permanently attached to deer because of our interest in mortality rates among different age classes.

We analyzed the suitability of these collars in several ways. 1) Because Bon and Cugnasse (1992) reported problems with collar fit when transmitters were attached, we tested for differences in the combined weights of collars and transmitters for the 3 brands of transmitters with a Kruskal-Wallis test, followed by an *a posteriori*

multiple comparison (Zar 1984). 2) We tested for differences in the proportion of males and females fitted with each type of transmitter, and in the proportion of collars still on animals after 1.5 years, with a G-test (Zar 1984). Because we used some transmitters more than once, the maximum length of time we considered in statistical analyses was 1.5 years. 3) We made observations from the ground and a helicopter in repeated efforts to detect collars that did not fit properly. 4) We examined carcasses of deer for any indication that these collars might have caused lesions or loss of hair (Bleich et al. 1990). 5) Further, we carefully examined collars retrieved from deer carcasses for evidence of material failure or construction flaws (Smith et al. 1998).

RESULTS

Mean weights of the 3 brands of transmitters when combined with the collars were significantly different ($H = 17.054$, $df = 2$, $P < 0.001$) (Table 1). Collars constructed with Lotek ($Q = 2.52$, $P < 0.05$) and ATS ($Q = 4.13$, $P < 0.05$) transmitters weighed less than those with Telonics transmitters, but did not differ from each other in weight ($Q = 1.92$, $P > 0.10$). Our subjective observations indicated that the heaviest collar-transmitter combination resulted in a looser fit on fawns than did

Table 1. Number and mean weight (± 1 SD) of transmitters and specially designed expandable collars placed on juvenile mule deer and proportion of collars remaining on deer after 1.5 years on the Round Valley winter range, Inyo and Mono counties, California, from 1994 to 1998.

Type of Transmitter	Sample Size		Weight (g) of transmitter and collar	Proportion of collars remaining after 1.5 years
	Male	Female		
Lotek	16 ^a	18 ^b	159.9 \pm 7.9	0.625
Telonics	11	18 ^c	270.5 \pm 3.4	0.750
ATS	22 ^{c,d}	24	143.8 \pm 7.2	0.822

^a One collar was removed from an animal after 1 year.

^b One transmitter failed and the collar was eliminated from the sample.

^c Includes 1 collar lost in an unknown manner

^d Includes 1 collar lost when it caught on a fence.

Table 2. Number of transmitters obtained from 3 manufacturers and year installed on mule deer fawns on the Round Valley winter range, Inyo and Mono counties, California, from 1994 to 1997.

Year	Manufacturer of Transmitter		
	Lotek	Telonics	ATS
1994	26	0	0
1995	3	27	0
1996	4	1	23
1997	1	1	23
Total	34	29	46

those weighing >100 g less (Table 1). This difference was no longer evident after fawns became yearlings.

During 1994–1997, we deployed these collars on 109 mule deer ranging in age from 6 to 9 months (Table 2). The proportion of males and females did not differ among the 3 types of transmitters ($G = 0.799$, $df = 2$, $P = 0.671$) (Table 1). One animal was removed from the data set when its transmitter failed, 2 animals lost their collars, and we replaced the expandable collar on a male with a standard adult collar when that animal was unintentionally recaptured 1 year after its initial date of capture (Table 1). These animals were not considered further in our analyses.

Thirty-nine collared animals died and we determined the cause of mortality for 28 (72%) of them. We also determined the date of death for 34 (87%) collared animals (B.M. Pierce and V.C. Bleich, unpublished data). Seventy-eight (74.3%) collared deer lived ≥ 1.5 years and 66 of these either remain alive or their status is unknown because transmitters ceased operating. The proportion of each type of transmitter remaining on animals 1.5 years after they were collared did not differ ($G = 3.818$, $df = 2$, $P = 0.153$) (Table 1).

During 9 aerial surveys conducted in January and March from 1995 to 1998, we repeatedly observed collars on adult deer that had been placed on them when they were fawns. We made similar observations from the ground regularly during November–April from 1994 to 1998. Although we did not record the number of animals observed with fawn collars during those surveys, we saw no collars that appeared to fit too tightly on adults. We substantiated these observations among 25 carcasses that were suitable for examination; none of these exhibited hair loss or other evidence of poor collar fit. We carefully examined 42 collars after they had been on animals 5–1,029 days (mean = 442, $SD = 333$). Among these collars, including 6 that had been on deer ≥ 2.5 years, there was little wear on the stitching. Moreover, fraying of the ends of the tubular webbing or snagging of the collar on brush did not appear problematic in terms of collar integrity.

DISCUSSION

The length of time that these collars have remained on deer and their good condition indicate that collars of this design, when attached to transmitters suitable for juvenile mule deer, are sturdy and dependable.

Similar to Bon and Cugnasse (1992), we detected a tendency for collars with the heaviest transmitters to not fit snugly around the necks of juveniles. This was likely a consequence of the elastic being stretched beyond the circumference of the neck by the added weight. Only 1 of the heaviest transmitters, however, was lost by a fawn (Table 1). Investigators using collars of this type to attach transmitters to juvenile ungulates should consider the weight of the transmitter, especially given the types of injuries that can be incurred from loose-fitting collars (Bleich et al. 1990).

Investigators must consider their research objectives carefully, including the size of the animals at the time of capture, how long transmitters will be monitored, maximum expansion of the collar, and durability of the collar material if collars are

not to be retrieved (Smith et al. 1998). We designed our collars to remain permanently attached (although the transmitters ultimately would fail), but not to be detrimental for adults. This strategy allowed us to determine cause-specific mortality and the date of death for the majority of the animals that died and these data will be used to estimate survivorship rates among fawn cohorts, thereby meeting study objectives. As designed, the collars provided adequate expansion capability for growth of animals.

During our study, transmitter life, and not durability of collar material, limited our efforts to monitor survivorship and cause-specific mortality of juvenile mule deer. Transmitters were retained by 78 deer after 1.5 years and the proportion that was retained did not differ among transmitter types (Table 1). The apparent positive trend in proportion of collars remaining after 1.5 years (Table 1) may reflect variability in mortality rates among years that the majority of each type of transmitter was deployed (B. Pierce and V. Bleich, unpublished data).

Bon and Cugnasse (1992) suggested their collar design might be of value to investigators studying juvenile ungulates other than mouflon sheep. Our results are consistent with their suggestion and, given the cost of the collar materials (\leq US\$3.00/collar, including stitching by a cobbler) when compared to commercially available expandable collars (about \$40.00/collar), investigators might wish to fabricate their own. We plan to use this type of transmitter attachment in future investigations and currently are evaluating the efficacy of this technique for attaching transmitters to juvenile mountain sheep, *Ovis canadensis*.

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MOVEMENT PATTERNS AND SURVIVORSHIP OF BLACK-TAILED DEER MIGRATING ACROSS TRINITY RESERVOIR, CALIFORNIA

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We assessed seasonal movement patterns and survivorship of black-tailed deer, *Odocoileus hemionus columbianus*, crossing Trinity Reservoir (Clair Engle Lake) in northern California by monitoring 2 fall and 2 spring migrations, beginning in fall 1993. Black-tailed deer traversed the reservoir using 43 routes located predominately in the narrowest sections of the reservoir. A group of 2–3 black-tailed deer typically swam together. Adult males and females were segregated by sex, but not by date. We estimated that as many as 389 black-tailed deer swam across the reservoir during daylight in a single migration. Two hundred and ninety-two of 302 black-tailed deer observed swimming crossed successfully. The fate of the remaining 10 was not determined. Trinity Reservoir does not appear to be a major mortality source for migrating black-tailed deer when it is ice free.

INTRODUCTION

In 1963, the Trinity River Division, Central Valley Project, filled Trinity (Clair Engle Lake) and Lewiston reservoirs to develop additional water supplies for irrigation and power, inundating an area of about 7,000 ha at a pool level of 723 m (USFWS² 1975). Land below the pool level represented ancestral migration routes and important wintering areas for black-tailed deer, *Odocoileus hemionus columbianus* (USFWS³ 1951, USFS⁴ 1960, USFWS² 1975). Reservoir construction

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² (USFWS) U.S. Fish and Wildlife Service. 1975. Deer loss compensation program resulting from Trinity River Division, Central Valley Project, California: A report to the Trinity River Basin Fish and Wildlife Task Force. Portland, Oregon, USA.

may have altered black-tailed deer migration routes by displacing them and constraining some to travel routes traditionally used by other deer (Loft⁵ 1983, Loft et al. 1984, USFWS³ 1975).

Black-tailed deer swimming the reservoir during migration (Loft⁵ 1983, Loft et al. 1984, Boroski and McLaughlin 1994) and isolated cases of deer drowning when the reservoir is partially frozen have been documented (Ashcraft⁶ 1970, USFWS³ 1975). The mortality rate due to drowning among black-tailed deer that swim across Trinity Reservoir when thawed is unknown. Our objective was to describe the seasonal movement patterns of swimming black-tailed deer and determine the baseline drowning rates during migration when the reservoir is ice free.

STUDY AREA

Trinity Reservoir is located about 13 km north of Lewiston, California within the range of the Weaverville deer herd which occupies about 2,070 km² in the drainage of the main stem of the Trinity River (Burton and Monroe⁷ 1983) (Fig. 1). Areas occupied by black-tailed deer range in elevation from 450 m along the Trinity River to 2,400 m in the Trinity Alps Wilderness. About 80% of the black-tailed deer migrate, the remainder are resident (USFWS³ 1975, Loft et al. 1984, Boroski⁸ 1998).

METHODS

We established 16 monitoring sites along the shore of Trinity Reservoir (Fig. 1), 12 of which were monitored during the spring or fall migration. Because black-tailed deer hesitate to move past people and enter the water (Boroski and McLaughlin 1994), 4 sites in the narrowest section of the reservoir on the shoreline where deer initiated their swim were not monitored during each migration. The 12 sites were monitored over two 6-hour periods, 0700 to 1300 and 1300 to 1900.

³(USFWS) U.S. Fish and Wildlife Service. 1951. Trinity River Division, Central Valley Project, California. Preliminary evaluation report on fish and wildlife resources. Weaverville, California, USA.

⁴USFS. 1960. Impact of Trinity River Project on Shasta-Trinity National Forests, summary report. USDA Forest Service, Region 5, San Francisco, California, USA.

⁵Loft, E.R. 1983. Seasonal migration of black-tailed deer in northern California. M.S. Thesis, University of California, Davis, California, USA.

⁶Ashcraft, G.C. 1970. Job progress report on wildlife population response to habitat manipulation. Unpublished report, California Department of Fish and Game, Sacramento, California, USA.

⁷Burton, T.S. and G.S. Monroe. 1983. Weaverville deer herd management plan. California Department of Fish and Game, Sacramento, California, USA.

⁸Boroski, B.B. 1998. Development and testing of a wildlife habitat relationships model for Columbian black-tailed deer, Trinity County, California. Ph.D. Dissertation, University of California, Berkeley, California, USA.

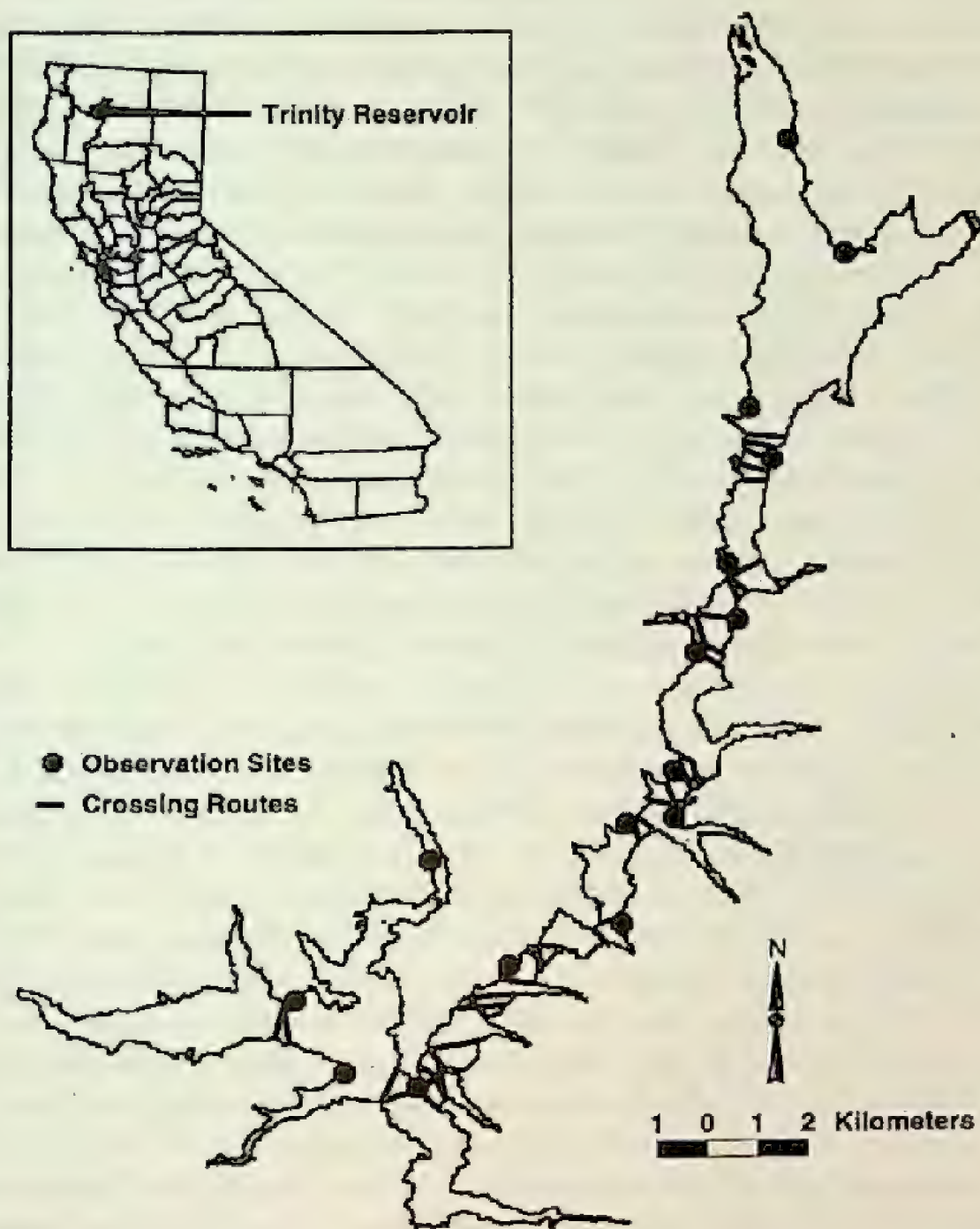


Figure 1. Observation sites and routes used by black-tailed deer to swim across Trinity Reservoir in Trinity County, California, 1993–1995.

during the peak of migration as determined by the movement of radio-collared black-tailed deer (Boroski⁸ 1998). The order that sites were monitored and observers were assigned to sites was randomly determined without replacement. For each of 4 migrations (fall 1993, spring 1994, fall 1994, spring 1995), we used binoculars and spotting scopes to observe black-tailed deer and recorded the time of day, crossing location, direction of travel, time spent swimming, group size, group composition, and the number of deer successfully swimming across the reservoir. Body size or the presence of antlers were used to classify animals as fawns of the year or adults. Drowning rates were determined by direct observation.

Variation in group size by year and migratory period was determined using Kruskal-Wallis and Mann-Whitney U tests, respectively (Zar 1984). The relationship between the time spent swimming and group size, crossing route, and migratory period was determined using a general linear model (Zar 1984). We used a log-likelihood ratio test (Zar 1984) to compare the sex composition among social groups during fall migration. Spring compositions were not identified because the inability to distinguish between fawns and females, and antlerless males and females, during the spring migration precluded reliable sex and age class determinations. Fall social groups (>1 deer) were defined as male, female, or mixed. Male groups consisted of antlered males, whereas female groups contained females older than 6 months with or without fawns (≤ 6 months old). Mixed groups included antlered males and females ≥ 1 year of age. The expected frequencies of single sex and mixed groups were calculated from the median fall group size and the probability of drawing male groups, females groups, and mixed groups of this size given the fall male: female ratio observed during the 1993 and 1994 fall migrations. We used a Mann-Whitney U test to assess temporal separation between the sexes by comparing the Julian dates that male and female groups crossed the reservoir.

To provide a frame of reference for interpreting the significance of drowning rates, we estimated the number of black-tailed deer swimming the reservoir during each migratory period. The number of black-tailed deer swimming the reservoir during our sampling periods was derived by multiplying the area of the lake (44.56 km^2) by the product of the estimates of the mean density of groups in the areas monitored (groups/ km^2) and the mean number of animals per group (deer/group) (Goodman 1960, Reed et al.⁹ 1989). Because wind, precipitation, and fog affected visibility, each time a site was used the size of the search area from the site was recalculated. The maximum distance black-tailed deer could be seen from the site was delineated on a map and later digitized into a geographic information system (ARC/INFO Version 7.0, Environmental Systems Research Institute, Inc.¹⁰, Redlands, California, USA) to calculate the area monitored.

To extend our estimate of the number of black-tailed deer swimming from our sampling period to the entire migratory period, we radio-collared 49 female deer (Boroski⁸ 1998). The number of black-tailed deer swimming during the migration was estimated by dividing the estimate of the number of deer that crossed during our sampling period by the proportion of radio-collared deer that returned to or departed from the winter range during the sampling period. Determining their return and departure was facilitated, in most cases, by black-tailed deer immediately swimming across the reservoir prior to their return or upon departure. The delta method was used to estimate the confidence intervals for the ratios (Bishop et al. 1980).

⁹Reed, D.J., L.L. McDonald, and J.R. Gilbert. 1989. Variance of the product of estimates. Unpublished report. Alaska Department of Fish and Game, Fairbanks, Alaska, USA.

¹⁰Reference to trade names does not imply endorsement by the U.S. Department of Agriculture or the California Department of Fish and Game.

RESULTS

We observed 302 black-tailed deer, in 111 groups, swimming across Trinity Reservoir from fall 1993 through spring 1995. One hundred and ninety-seven were adults, 74 were fawns, and 31 could not be classified. Of the 302 black-tailed deer, 292 crossed successfully. We observed no drownings. The fates of 2 adults, 1 fawn, and 7 of unknown age could not be determined.

Median group size was 2.0 black-tailed deer (range = 1–9) and did not vary by year ($H = 5.441$, $P = 0.142$); however, groups were 50% larger in the spring ($n = 78$, median = 3) than in the fall ($n = 32$, median = 2) ($U = 1,775$, $P < 0.0005$).

Over all years, the fall male:female ratio was 17:100 and the fall fawn:adult ratio was 36:100. Based on a fall median group size of 2.0 deer and a male:female ratio of 17:100, the expected frequencies of male, female, and mixed social groups were 2%, 73%, and 25%, respectively. The observed frequencies were different than expected ($G = 8.528$, $df = 2$, $P < 0.025$; male groups: observed = 4, expected = 0.54; female groups: observed = 22, expected = 19.71; mixed groups: observed = 1, expected = 6.75). Male and female groups crossed the reservoir on similar dates ($U = 70$, $P = 0.40$).

Black-tailed deer moved east and south across the reservoir during fall migration and west and north during spring. For 100 groups, we identified 43 separate routes, averaging 585 m long ($n = 43$, $SD = 235.3$, range = 56–1,086), used to cross the reservoir (Fig. 1). On average, groups of black-tailed deer swam for 11.4 minutes ($n = 75$, $SD = 4.7$, range = 2.5–23). Swimming duration varied with route used ($F = 2.326$; $df = 1, 27$; $P < 0.05$) and migratory period ($F = 5.006$; $df = 38, 29$; $P < 0.05$). Only 23% of the routes were used during both spring and fall migrations, the rest were used exclusively during the spring or fall. The difference between the adjusted least square means indicated it took on average 31% more time to cross the reservoir by the routes used in the spring versus those used in the fall. Swimming time was not related to group size ($F = 0.011$, $df = 1, 27$, $P = 0.915$).

The mean density of groups of swimming black-tailed deer ranged from 0.26 to 0.60 groups/km² (Table 1). The fall migration took 3 times as long as the spring migration (Boroski⁸ 1998) and influenced the proportion of radio-collared black-tailed deer that migrated during the period swimming deer were monitored (Table 1). Estimates of the number of black-tailed deer that swam the reservoir

Table 1. Proportions of radio-collared black-tailed deer migrating during 6-day monitoring periods and estimates of the number of deer crossing Trinity Reservoir.

Migratory period	Groups/km ²			Deer/group			Proportion migrating	Estimated No. \pm 95%CI crossing
	<u>n</u>	<u>Mean</u>	<u>SD</u>	<u>n</u>	<u>Mean</u>	<u>SD</u>		
Fall 1993	18	0.29	0.39	9	1.67	0.87	0.21	103 \pm 286
Spring 1994	20	0.60	0.80	24	3.17	1.88	0.82	103 \pm 249
Fall 1994	17	0.26	0.43	12	2.00	0.95	0.24	97 \pm 291
Spring 1995	25	0.37	0.56	17	2.76	1.52	0.57	80 \pm 220

during migration were consistently about 100 animals, but had large confidence limits (Table 1). The estimated number of black-tailed deer swimming the reservoir during daylight in a single migration was between 76 and 389 based on the population estimates and the largest number of deer observed swimming during a single migratory event (76 during the spring migration of 1994).

DISCUSSION

The absence of confirmed drownings led us to conclude, as others have (Sheldon 1912, Cowan 1956, Robinette 1966, Boroski and McLaughlin 1994), that black-tailed deer are strong swimmers and, furthermore, that Trinity Reservoir is not a major source of mortality when it is ice free. Mortality data for 13 adult radio-collared does that crossed the reservoir during migration suggests that stress associated with crossing the reservoir during typical climatic conditions does not predispose adults to other mortality factors (Boroski⁸ 1998). Only 3 of these died within 1 month of crossing the reservoir, 1 of undetermined causes after reaching the summer range 22 days later and 2 of predation by mountain lions, *Felis concolor*, 16 and 21 days after crossing the reservoir (B. Boroski, unpublished data). Data of this type are needed for fawns and during winter storms that impede locomotion (Harestad et al. 1982) to further assess the indirect effects of migrating across Trinity Reservoir.

The smaller group size during fall migration was consistent with previous findings that family groups composed of does, fawns, and yearlings moved from summer range to winter range independently of other groups (Gruell and Papez 1963). Based on the behavior of female radio-collared black-tailed deer, the period that deer crossed the reservoir during the fall migration was about 3 times longer than in spring (Boroski⁸ 1998). We hypothesize that the larger groups in spring were the result of the more synchronous spring migration (Boroski⁸ 1998). The differences in the synchrony of migration and the formation of larger groups might partially explain why 77% of the routes were used exclusively during fall or spring migration.

Despite their reported ability to swim several kilometers (Cowan 1956), black-tailed deer crossed at the narrower sections of Trinity Reservoir. Robinette (1966) reported mule deer, *Odocoileus hemionus*, swimming about 0.8 km across Yuba Reservoir and 0.3 km across Flaming Gorge Reservoir during migration, distances that suggest mule deer also crossed at narrow sections of those reservoirs. When assessing the impact of proposed reservoirs on migratory black-tailed deer herds, it may be prudent to consider where narrow sections will occur and compare those locations with the historic migratory patterns of deer and planned human developments.

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STRANDING RECORDS OF THE OARFISH IN AND AROUND BAHIA DE LA PAZ, MEXICO

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The Order Lampridiformes is composed of 21 species (Olney 1984). It is a highly specialized and divergent group in terms of morphology and life history (Nelson 1994). The most impressive members of the order are in the family Regalecidae, the oarfish. This family contains only 1 genus, *Regalecus*, and most ichthyologists recognize the genus as monotypic, with *R. glesne* as the oldest available name (Nelson 1994). Oarfish are, in some cases, responsible for historic sightings of sea monsters (Olney 1984).

Oarfish are distinguished by having an elongate body up to 17 m total length (TL) (Olney et al. 1993), a head with an occipital cockscomb, an almost vertical protacile mouth, and pelvic fins composed of just 1 elongated ray (Bauchot 1995). They are mesopelagic and are found in all oceans, except in polar regions. Most records have occurred in tropical, subtropical, and upwelling areas (Olney 1984).

A total of 9 strandings (11 individuals) of oarfish was reported from 1984 to 1996 in and around the Bahía de La Paz (Fig. 1, Table 1). The 1st published record of a Mexican *Regalecus* specimen was from El Tecolote on 16 June 1985 (Chávez et al. 1985). Additional information has been generated from dead or dying specimens, but none of it has been published (Castro-Aguirre et al. 1991). On 1 July 1984, a specimen identified as *Regalecus russelli* was captured and taken to the Natural History Museum of the Universidad Autónoma de Baja California Sur (UABCS No. 0752). It was 197 cm TL and collected at Playa Pichilingue. On 1 June 1988, a stranding of a 2nd specimen was reported at Punta Colorada. This fish measured 490 cm TL, but no further data were collected. Almost a year later, on 2 May 1989, another *Regalecus* (450 cm TL) was found, this time in the fishing village El Quelele. Again, no more data are available.

During 1991, 3 strandings occurred. The 1st specimen (28 May) resulted in the description of a new species, *Regalecus kinoi* (Castro-Aguirre et al. 1991), because it differed in some morphological characters from *R. russelli*, especially the number of spines in the crest and the pectoral fin length. The other 2 strandings (both in June) were of 2 individuals each, an uncommon phenomenon; only the total length and location were recorded (Table 1).

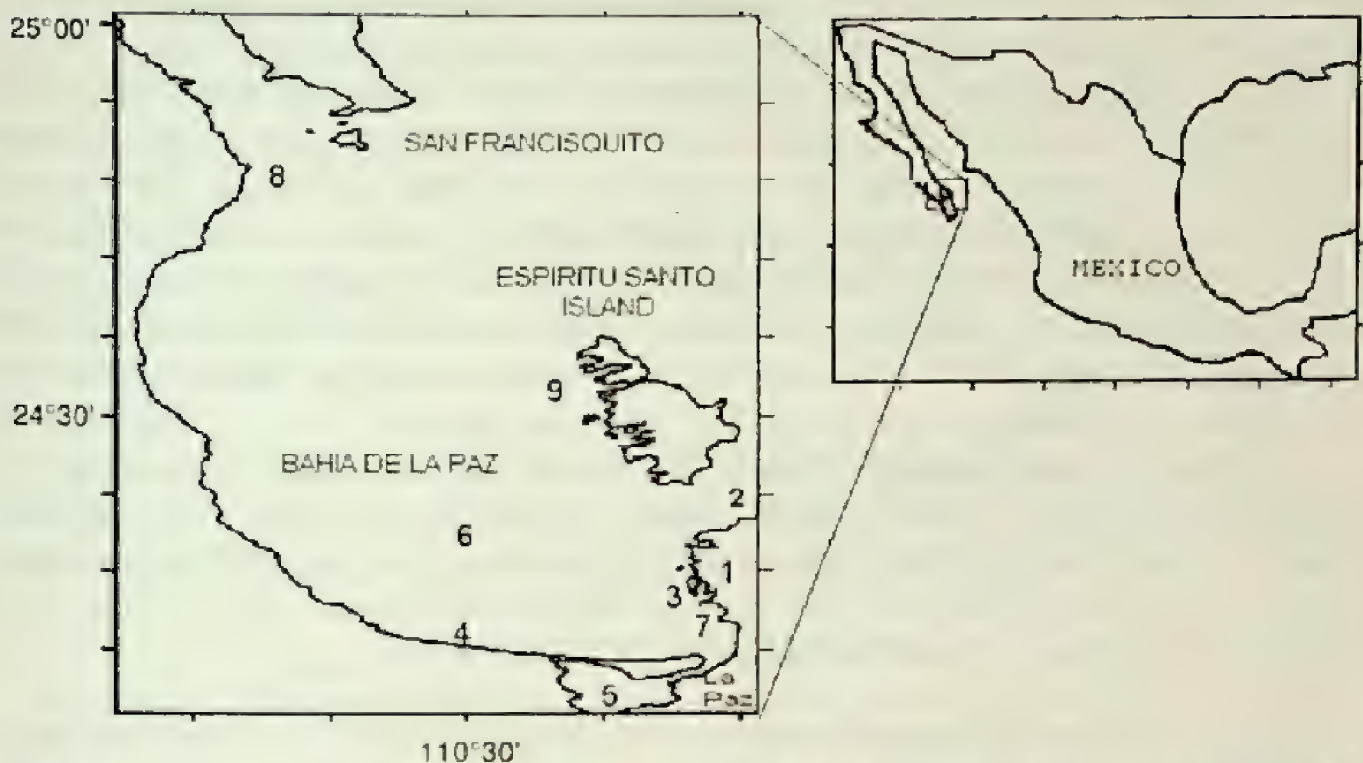


Figure 1. Locations of *Regalecus* strandings. Numbers are given in chronological order according to the stranding records: 1. Playa Pichilingue, 2. El Tecolote, 3. Punta Colorada, 4. El Quelele, 5. Ensenada de La Paz, 6. Bahía de la Paz, 7. Costa Baja, 8. Punta Mechudo, 9. Ensenada Grande.

Table 1. Known stranding records of *Regalecus* in Baja California Sur. Numbers indicate the stranding incident, as in Fig. 1. *Regalecus* sp. reports were anecdotal, so no more information was available.

Stranding Number	Date	Species	Locality	Observations
1	1 July 1984	<i>R. russelli</i>	Playa Pichilingue	197 cm, not published
2 ^a	16 June 1985	<i>R. russelli</i>	El Tecolote	1 st record, 393 cm
3 ^b	1 June 1988	<i>Regalecus</i> sp.	Punta Colorada	490 cm
4 ^b	2 May 1989	<i>Regalecus</i> sp.	El Quelele	450 cm
5 ^a	28 May 1991	<i>R. kinoi</i>	Ensenada de La Paz	New species, 470 cm
6 ^b	June 1991	<i>Regalecus</i> sp.	Bahía de La Paz	2 individuals, 121 kg, 136 kg
7 ^b	16 June 1991	<i>Regalecus</i> sp.	Costa Baja	2 individuals, both >400 cm
8 ^b	10 March 1995	<i>Regalecus</i> sp.	Punta Mechudo	478 cm
9 ^c	16 July 1996	<i>R. russelli</i>	Ensenada Grande, Isla Espíritu Santo	530 cm

^a Published records

^b Fishermen reports (anecdotal)

^c This report

On 10 March 1995, a 480-cm *Regalecus* off Punta Mechudo was reported to 1 of the authors without any additional details.

Most recently, on 16 July 1996, G. Willis of the *FV WILD GUESS II* delivered to the authors the head and total length measurement (530 cm) of a *Regalecus* found adrift in Ensenada Grande, Isla Espíritu Santo. The specimen was identified as

R. russelli, agreeing with Castro-Aguirre et al. (1991), although it shared some of the taxonomic features of *R. kinoi* (Table 2).

It is interesting that all of these strandings occurred in or near Bahia de La Paz (24°30'N, 110°30'W) (Fig. 1). Perhaps because it is the most visited and populated area, it is more common to find and report stranded fish there.

In all the reported strandings, only total length or weight was recorded because the discoveries were made by either fishermen or tourists and the strandings were documented by phone calls or publication in the press. In most cases, no more information was available and a lack of communication made getting any additional information impossible.

All the strandings occurred between March and July. A similar seasonal pattern has been observed in Florida for *R. glesne* (Saloman et al. 1973), but no good explanation has been offered. Proffered explanations involve speculation about diseases (Parin 1970), red tides, storms, migratory movements, or shark attacks (Fitch and Lavenberg 1968, Taylor and Saloman 1968, Saloman et al. 1973).

Table 2. Comparison between *Regalecus russelli* and *R. kinoi*. Except for total length, measurements are given as percent of total length. The information from strandings 2 and 5 was taken from published articles. In specimens 1 and 9, we measured each character with rulers and verniers and the observations were made with a magnifying glass and stereoscope. NE = not evident, NM = not measured.

Character	Specimen			
	No. 1 <i>R. russelli</i>	No. 2 <i>R. russelli</i>	No. 9 <i>R. russelli</i>	No. 5 <i>R. kinoi</i>
Total length (cm)	197	393	530	470
Head length	8.5	6.74	6.13 ^a	7.93
Head height	6	NM	8.86	8
Ocular diameter	1.45	0.84	0.98	1
Pectoral fin length	1.65	1.01	2.07 ^b	3.36
Pectoral fin base length	1.5	NM	1.18	1.15
First gill arch length	NE	NM	4.05	6.21
Longest gill filament	1.2	NM	1.32	1.51
Shortest gill filament	0.6	NM	0.37	0.27
Pairs of gill filaments	+200	NM	216	240
Gillrakers of the first arch	46	55	49	60
Branches in each gillraker	10	NM	17	18–20
Branchiostegal rays	6	6	6	NM
Number of long dorsal spines	6	6	6	3
Pectoral fin rays	11	13	12	11

^a Head length measured from the posterior margin of the mouth to the posterior margin of the operculum.

^b Incomplete pectoral fin.

For the 1996 specimen, we obtained the head and some other morphometric data and taxonomic features that let us unequivocally identify the fish. We discovered that it shared some important features with the recently described *R. kinoi*. However we were unable to locate the holotype specimen of *R. kinoi* in the UABCS Natural History Museum; it may be lost.

The comparison showed that the 1996 fish and the *R. kinoi* specimen both had dorsal spines without bulbs, a convex margin of the head, and a lanceolate pectoral fin >11 cm long. They also shared the same proportionality of head height, ocular diameter, pectoral fin length, pectoral fin base length. The number of branches in each gillraker was also similar (Table 2). The rest of the characters (cephalic length, longest gill filament, gillrakers on the first arch, and pectoral fin rays) of the 1996 specimen were similar to those of *R. russelli* (Fujii 1984). We strongly think that *R. kinoi* is a junior synonym of *R. russelli* and not a new species.

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EVIDENCE FOR FRESHWATER SPAWNING BY STRIPED MULLET AND RETURN OF THE PACIFIC TENPOUNDER IN THE LOWER COLORADO RIVER

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On 7 and 20 May and 10 June 1998, 10 striped mullet, *Mugil cephalus*, 56–71 mm total length (TL) were caught by dip net and seine from the Gila River, Yuma County, Arizona (32°44'32"N, 114°26'28"W). Five specimens (56–69 mm, mean = 64.8 mm) were preserved as vouchers (Arizona State University [ASU] Collection 16766 and 16767) and 5 (56–71 mm, mean = 61.6 mm) were released. These specimens, occurring at least 233 river km (rkm) up the Colorado and Gila rivers from the Sea of Cortez (Gulf of California), support Johnson and McClendon's (1970) hypothesis that mullet may spawn inland, somewhere on the Colorado River delta. They captured 31 postlarvae (28–40 mm standard length, mean = 32.4 mm) (ASU Collection 2293) below Morelos Dam in 1966, about 20 rkm downstream from the confluence of the Gila and Colorado rivers (approximately 193 rkm from the sea). Adult striped mullet typically spawn in the open ocean (Anderson 1958, Arnold and Thompson 1958). Larvae congregate in brackish-water bays and estuaries and grow for several months to >150 mm TL before tending to move into freshwater. Although direct observation of spawning activity or the presence of gravid adults in freshwater has not been documented, the occurrence of young mullet (<150 mm TL) as far up the Colorado River as the Gila River confluence is strong circumstantial evidence for freshwater spawning by this species. Minckley (1973) speculated that elevated salinity from agricultural runoff and other wastewaters might account for inland spawning in the Colorado River delta.

Since the mid-1970s, except for periods in 1983–84, 1993, and 1997–98, the Colorado River has failed to flow into the Sea of Cortez. Recent, El Niño-related rain and snowfall in the Colorado River basin resulted in substantial flow past Morelos Dam to the sea for most months in 1997 through January–April 1998 (as high as 332 m³/s in February 1998) (Carol Grimes, U.S. Bureau of Reclamation, Yuma, Arizona, USA, personal communication). This likely facilitated movement of striped mullet into riverine habitats. In fact, a 1993 flood in the Gila River (peak discharge, 906 m³/s) (Smith et al.¹ 1996) allowed adult mullet to move upstream to immediately below Painted Rock flood-retention reservoir (ASU 17195–17199).

¹ Smith, C.F. and 7 others. 1996. Water resources data for Arizona, water year 1995. U.S. Geological Survey, Water-Data Report AZ-95-1, Tucson, Arizona, USA.

approximately 400 rkm from the sea. The most upstream record for adult mullet in the Colorado River mainstem is approximately 300 rkm from the sea at Palo Verde Irrigation Diversion above Blythe, California (Rinne and Minckley² 1991).

Numerous Pacific tenpounders, *Elops affinis*, (locally called machete) were caught near the mouth of the Gila River and below during routine fisheries surveys by Arizona Game and Fish Department in fall 1997, marking a return of that species following a 17-year hiatus. Approximately 20 specimens were observed, 7 were measured (163–205 mm TL, mean = 183 mm), and 4 were preserved as vouchers (ASU 16768). The same high river flows that facilitated movement of striped mullet into riverine habitats probably affected Pacific tenpounders in the same manner.

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² Rinne, J.N. and W.L. Minckley. 1991. Native fishes of arid lands: A dwindling resource of the desert Southwest. General Technical Report RM-206, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

A FIRST MEXICAN RECORD OF THE CHINOOK SALMON, *ONCORHYNCHUS TSHAWYTSCHA*

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The family Salmonidae includes many important sport and commercial fishes. However, the species in the family are economically unimportant and practically nonexistent in Mexican waters: only 2 occur there as native species (Robins et al. 1991, Ruiz-Campos and Pister 1995). These species are the Mexican golden trout, *Oncorhynchus chrysogaster*, and the rainbow trout, *O. mykiss*. In this note, I report the occurrence of a chinook salmon, *Oncorhynchus tshawytscha*, for the 1st time in the Pacific Ocean off Mexico. This represents the southernmost marine record of this species in the eastern North Pacific and is more than 650 km south of its previous southern limit off San Diego, California (Miller and Lea 1972).

On 20 October 1996, a mature female chinook salmon was caught by hook and line in Bahía Sebastian Vizcaino (off Scammon Lagoon), Baja California Sur (B.C.S.), Mexico at 27°54'N, 114°17'W by a local angler. The specimen was identified by its body size; coloration (olive green with numerous irregular black spots on its upper side, back, and the entire caudal fin); and gums, which were black at the base of the teeth (Miller and Lea 1972, Goodson 1988). Morphometric (in millimeters) and meristic data for the specimen are as follows: total length 761, head length 186, eye diameter 21, preorbital distance 57, postorbital distance 108, interorbital distance 63, predorsal distance 354, body depth 163; fin rays counts: dorsal 13, anal 16, pectoral 15–16. Counts were made under a dissecting microscope after dyeing the fin rays with alizarin red. The specimen is catalogued in the ichthyological collection of the Centro Interdisciplinario de Ciencias Marinas, CICIMAR-CI 4526.

The chinook salmon has a widespread distribution in northern Pacific and Arctic waters from Japan to the Bering Sea, Alaska, British Columbia, Washington, Oregon and California. It enters streams primarily in the fall to spawn, often in large rivers, and some travel 600 miles inland (Goodson 1988). The date of appearance in B.C.S., its ripe gonads, and the practically nonexistent rivers or streams in northwest Mexico, suggest a case of extreme straying (*sensu* Hubbs 1946).

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FIRST RECORDS OF MORPHOLOGICAL ABNORMALITIES IN LEATHERJACK

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In November 1997, 4 specimens of leatherjack, *Oligoplites saurus*, were caught using a modified stationary flume net (Melvor and Odum 1986, Gonzalez-Acosta¹ 1998) deployed at the mouth of the tidal channel of El Conchalito mangrove swamp, Laguna de La Paz, Baja California Sur, Mexico (24°08'17"N, 110°22'51"W). Leatherjack were collected at temperatures ranging from 21.0 to 25.5°C, salinities from 37.1 to 41.5‰, and dissolved oxygen concentrations from 4.8 to 7.1 mg/liter. All specimens were deposited and catalogued in the ichthyological collection of Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN) (Series CI:4683).

X-ray photographs revealed anomalies in 2 specimens: a curvature of the spinal column between the 1st and 11th vertebrae (lordosis) in 1 fish (Fig. 1a), and a blunt and rounded apex of the upper jaw in the other fish (Fig. 1c) that differs from the normal mouth shape of leatherjack (Figs. 1b and d). This malformation is perhaps due to the reduction of the frontal, nasal, or maxillary bones. (The x-ray was not clear enough to say which bones were affected). The number of spines and soft rays in dorsal and anal fins were the same as those published (Smith-Vaniz 1995), but gill rakers were fewer than previously reported (Table 1).

Dawson (1964) and Dawson and Heal (1976) reviewed several cases of skeletal structural abnormalities in fishes; however, this is the first record of deformities in leatherjack. Most teratologies probably occur during embryonic and larval development, which are usually associated with skeletal anomalies (Koumondourous et al. 1997). Lordosis may be caused by genetic factors, i.e., mutation, or the absence of a functional swim bladder (Chatain 1994), or induced by adverse environmental factors, such as temperature (Kocan et al. 1996), ascorbic acid (vitamin C) and mineral deficiencies (Wimberger 1993). Exposure to genotoxic substances, such as pesticides, oil, and heavy metals may cause hereditary deformations of the skeletal structure of fish (Lindesjö and Thulin 1992) due to disorders in collagen metabolism in bones (Chatain 1994). However, several abnormalities in fish have been caused

¹ Gonzalez-Acosta, A.F. 1998. Ecología de la comunidad de peces asociada al manglar del estero El Conchalito, Ensenada de La Paz, Baja California Sur, Mexico. M.S. Thesis, Centro Interdisciplinario de Ciencias Marinas-IPN, Mexico.

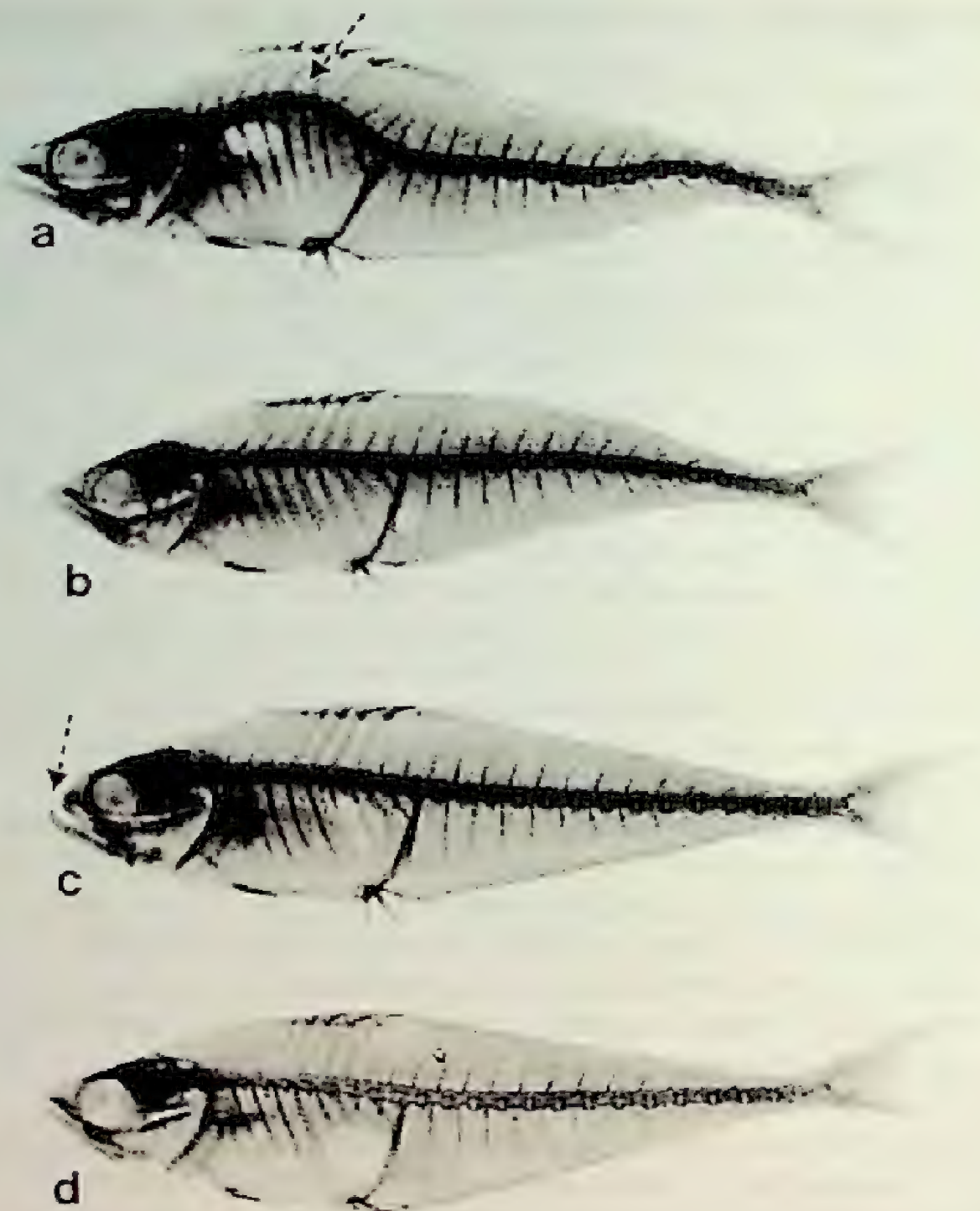


Figure 1. X-ray photograph of leatherjack specimens from El Conchalito mangrove swamp, Laguna de La Paz, Baja California Sur, Mexico. a) Specimen with lordosis, b) and d) normal fish and c) specimen with abnormal upper jaw.

by mechanical stress in aquacultural activities (Haaker 1977). The mandibular deformation observed here could be related to unfavorable environmental factors, as Carls and Rice (1990) consider extreme temperature as the main cause of deformed jaws.

Although lordosis and other anomalies have a negative influence on morphology, growth, and survival of fish, some abnormal individuals can survive in natural populations for several years, as did specimens of northern anchovy, *Engraulis mordax* (Haaker 1977).

Table 1. Measurements (mm) and counts of leatherjack specimens in Fig. 1: a) Individual with lordosis; (c) specimen with abnormal mouth, and normal fish (b and d).

Characteristics	Fish a	Fish b	Fish c	Fish d
Standard length	110.6	104.2	107.7	108.3
Total length	127.8	121.1	126.8	125.6
Head length	25.8	23.5	24.9	25.1
Lower jaw length	12.9	12.8	12.8	13.1
Upper jaw length	15.1	13.5	12.4	14.9
Ocular diameter	6.7	5.8	6.2	6.4
Pectoral fin length	14.9	14.2	15.2	15.1
Deep body	28.6	24.8	25.7	27.0
Dorsal fin	V+I, 20	V+I, 20	V+I, 19	V+I, 19
Anal fin	II+I, 19	II+I, 20	II+I, 19	II+I, 19
Gill rakers (upper + lower)	6+14=20	7+14=21	7+14=21	7+14=21
Number of vertebrae	26	26	26	26

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AN OBSERVATION OF BLUE SHARK PARTURITION IN THE SOUTHERN CALIFORNIA BIGHT

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Few observations of sharks giving birth in their natural habitat have been recorded. While conducting a shark research cruise in the Southern California Bight (the California coast between Point Conception and the Mexican border) a hooked blue shark, *Prionace glauca*, was observed giving birth to 4 pups. Though the parturition was likely stress-induced, the pups were apparently fully developed and healthy. This relatively rare occurrence suggests that the Southern California Bight may be part of a blue shark pupping ground.

The estimated length of maturity for female blue sharks falls between 140 and 250 cm total length (TL). Female blue sharks in the North Atlantic Ocean reach maturity at 180–190 cm fork length, based on the diameter of the largest ovarian eggs (Pratt 1979). Mature females in the North Pacific Ocean are between 140 and 160 cm precaudal length, based on uterus width (Nakano 1994). Cailliet and Bedford (1983) summarized female blue shark size at maturity as being reached between 180 and 250 cm TL.

Blue sharks reproduce by placental viviparity; the embryo's yolk sac develops into a placenta analogous to that of mammals (Pratt 1979). Usual litter size ranges from 4 to 82 pups (Eschmeyer and Herald 1983), but may reach 135 (Gubanov and Grigor'yev 1975). The size-at-birth of blue shark pups ranges between 30 and 60 cm TL (Pratt 1979, Cailliet and Bedford 1983). Strasburg (1958) described a large female blue shark giving birth after being landed on the deck of a research vessel. The pups ranged between 34 and 48 cm and appeared fully developed and active.

The observed parturition occurred west of Avalon Bank, Santa Catalina Island (33°29'N, 118°19'W) on 15 June 1995. The shark was caught during a longlining and tagging cruise on board the Department of Fish and Game R/V *MAKO*. It was hooked in the jaw and had been on the line for ≤ 2 hours. The births took place after the shark was tagged using a stainless steel dart tag. The shark was estimated to measure more than 200 cm TL, exceeding the minimum length for size at maturity.

Four pups were born over a period of 5 minutes as the shark was prepared for release. Given the large average litter size of blue sharks, other births may have occurred unobserved. The pups' lengths were estimated to be between 30 and 40 cm TL, though each was fully visible for < 1 second. These lengths are at the low end of the estimated range of size at birth. After birth, all 4 pups actively swam towards the bottom. No umbilical cord or bleeding was visible from either the mother or pups.

Although the pups appeared to be near full term, this was not a naturally occurring birth. Parturition was likely to have been stimulated by the stress of capture and

tagging. Previous data suggests that the Southern California Bight is a pupping area for sharks; free-living young and near-term pregnant blue sharks have been documented in the Southern California Bight on 15 previous occasions (Feder et al. 1974, Anonymous¹ 1981). Although Department of Fish and Game shark tagging cruises observe a wide size range of blue sharks, 86% are juveniles <180 cm TL. Nakano (1994) suggests that blue shark mating occurs between 20° and 30°N during summer months and pupping between 30° and 40° N the following summer. Pratt (1979) describes Atlantic blue sharks giving birth in late May and June. The births described here occurred within Nakano's suggested parturition area and both Nakano's and Pratt's described time of year for pupping. This observation demonstrates that blue sharks with late-term, viable young are present in the Southern California Bight and suggests that the bight is part of a blue shark pupping ground.

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A BLOOD FLUKE FROM A NORTHERN PINTAIL IN CALIFORNIA

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Dendritobilharzia pulverulenta (Family Schistosomatidae) is a trematode that commonly inhabits the dorsal aorta of waterbirds, particularly waterfowl (McDonald 1969, 1981). A detailed morphological description of this schistosome has been given by Ulmer and Vande Vusse (1970). Briefly, both sexes have an elongated, flattened body that is slightly tapered anteriorly and posteriorly. The male body length is 2.95–13.0 mm and the female body length is 3.35–10.37 mm. The male lacks a gynecophoral canal and, unlike other trematodes, both sexes in the genus *Dendritobilharzia* lack oral and ventral suckers. Typically, trematodes in this family of blood flukes inhabits veins, whereas *D. pulverulenta* inhabits arteries.

Little is known about the life cycle of *D. pulverulenta* in North America. Both cercaria and the intermediate host(s) are unknown (Farley 1971). However, Khalifa (1976) documented 2 molluscan intermediate hosts (*Anisus vortex* and *Planorbis planorbis*) in Poland. Definitive host infection occurs from penetration of the skin by furcocercous cercaria (McDonald 1981).

A hunter-taken, adult female northern pintail, *Anas acuta*, was collected near the north shore of Humboldt Bay, Humboldt County, California in October 1981. The viscera was removed from the body cavity and the tissues were examined for parasites. Trematodes were preserved in alcohol-formalin-acetic acid solution, stained with acetocarmine or hematoxylin (Meyer and Olsen 1980) and identified to species using taxonomic keys in Yamaguti (1958) and McDonald (1981).

During necropsy, 1 male *D. pulverulenta* was discovered in each kidney. No other parasites were observed in other tissues. As *D. pulverulenta* normally inhabits the dorsal aorta and its branches (McDonald 1981, Ulmer and Vande Vusse 1970), the kidneys are not the normal definitive site. However, Cornwell and Cowan (1963) observed this schistosome in the liver and kidneys of canvasbacks, *Aythya valisineria*. These authors suggest that these tissues may have been inhabited due to post-mortem migration through the arterial system in search of oxygenated blood. Additionally, chronic enteritis and ureteritis caused by *D. pulverulenta* eggs passing through the intestinal and ureter walls are not uncommon in waterfowl (Wobeser 1981). Focal granulomas have also been found surrounding eggs in liver and kidney tissues of apparently healthy ducks (Wobeser 1981).

Although the life cycle of *D. pulverulenta* in North America is unknown, a mollusk similar to those described by Khalifa (1976) is likely the intermediate host.

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"Swimmer's itch," caused by intermediate life-stage furcocercous cercaria, has been reported in humans who swim in Californian's north coast rivers (H. Wethery, Humboldt County Division of Environmental Health, Eureka, California, personal communication). The geographical location where this adult northern pintail became infected with *D. pulverulenta* is unknown, due to the migratory nature of this species.

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